MAHON, R. 2023. Sand management and control in the energy transition: state-of-the-art and future directions. Presented at the 2023 Sand Management Network (SMN): beyond oil and gas; sand control, 25 May 2023, Bergen, Norway.

Sand management and control in the energy transition: state-of-the-art and future directions.

MAHON, R.

2023

Sand Management and Control in the Energy Transition: State-of-the-art and Future Directions

Beyond Oil and Gas - Sand Control

Bergen, Norway

25th May 2023

Dr Ruissein Mahon

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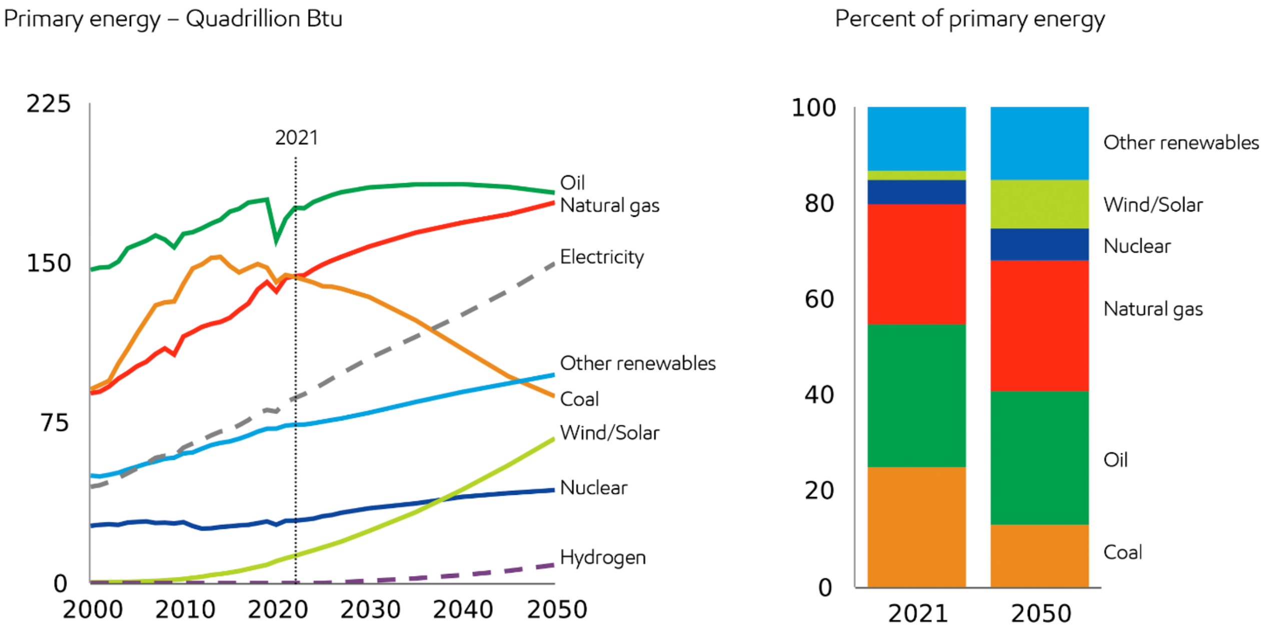
Contents

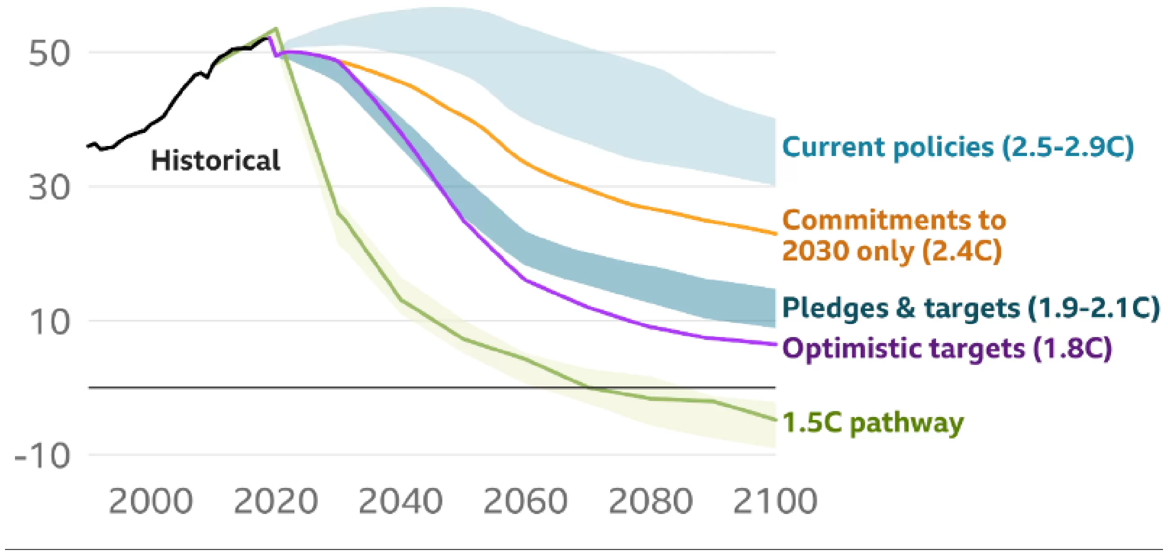
- Energy landscape
- Climate technologies / decarbonisation tools
  - Geothermal energy systems
  - Underground hydrogen storage (UHS)
  - Carbon capture and storage (CCS)
- Operational challenges
- Opportunities
- Looking forward

Changes in the Energy Ecosystem

- Oil continues to play a leading role in the world's energy mix
- Natural gas grows over the period
- Renewables and nuclear will contribute ~ 65% of incremental energy supplies



Global energy mix shifts to lower-carbon fuels (Outlook for Energy, 2019)



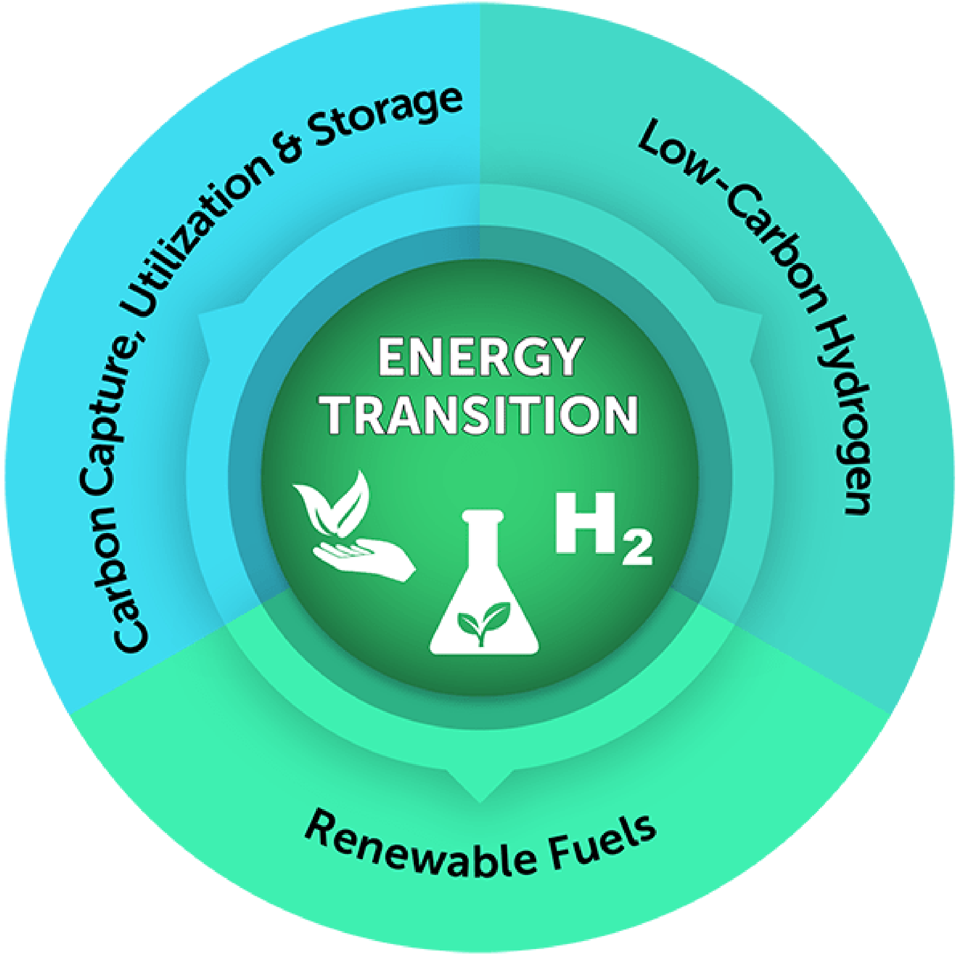
Global GHG emissions in gigatonnes of CO_2e (Climate Action Tracker, 2022)

Energy Transition

- Energy system changes are required to achieve GHG emission targets
- Climate technologies and decarbonisation tools required to accelerate the move towards net zero energy system

Global markets

- **Geothermal:** USD 62.65 billion, expected to grow to USD 95.82 billion by 2030
- **Hydrogen:** USD 170.14 billion, expected to expand to USD 317.39 billion by 2030
- **CCS:** USD 3.47 billion, expected to grow to USD 5.61 billion by 2030



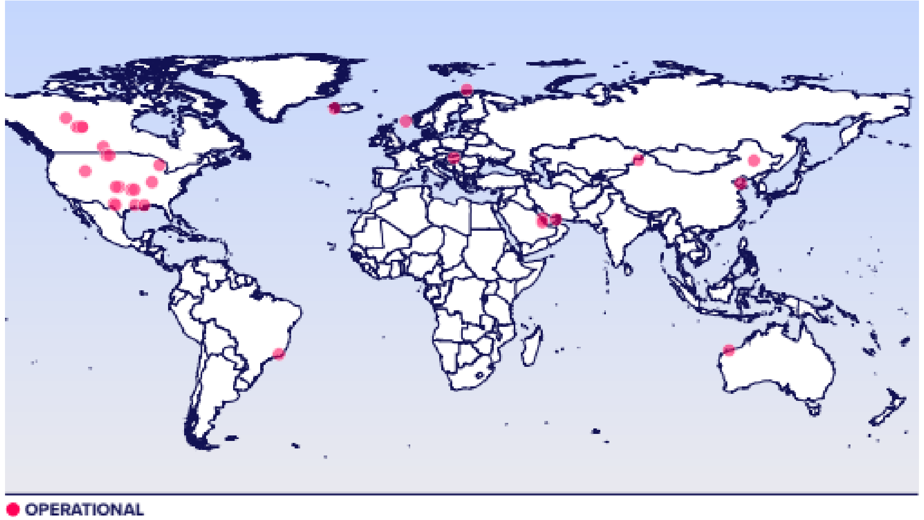
Tools to facilitate the energy transition (DistributionNOW, 2023)

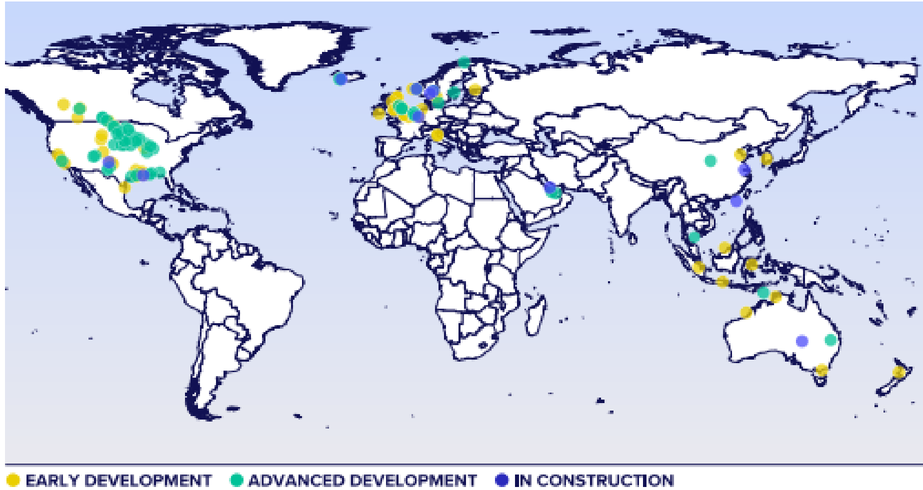
Global CCS Facilities

- CCS, identified as a critical tool to address the climate crisis – tackles climate change and supports the delivery of climate neutrality
- Over 190 facilities are in the project pipeline with a total capacity of 244 Mtpa
- Strong growth a direct result of private sector's response to move to a net zero emissions and the evolution of government policy and regulation

Commercial CCS facilities (Global CCS Institute, 2022)

Projects	Number	Capacity (Mtpa)
Operational	30	42.5
In construction	11	9.6
Advanced development	78	97.6
Early development	75	91.8
Operation suspended	2	2.3

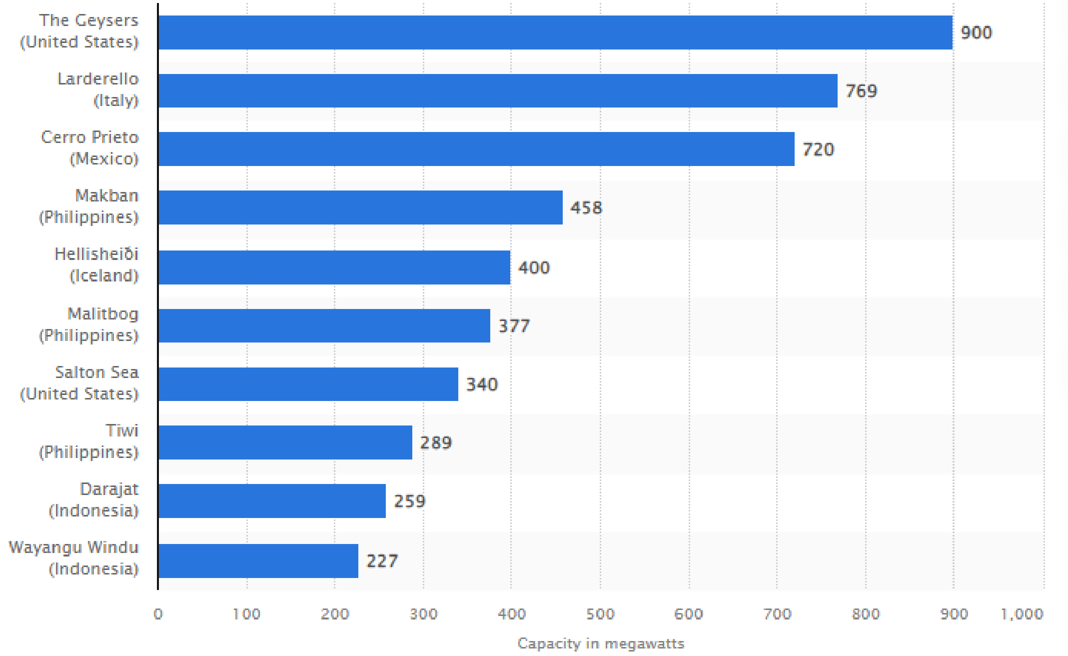




CCS facilities - developmental stages (Global CCS Institute, 2022)

Global Geothermal Projects

- Low-emissions, environmental-friendly and potentially sustainable energy supply
- Many thick sedimentary basins that contain abundant sandstone-type geothermal resources

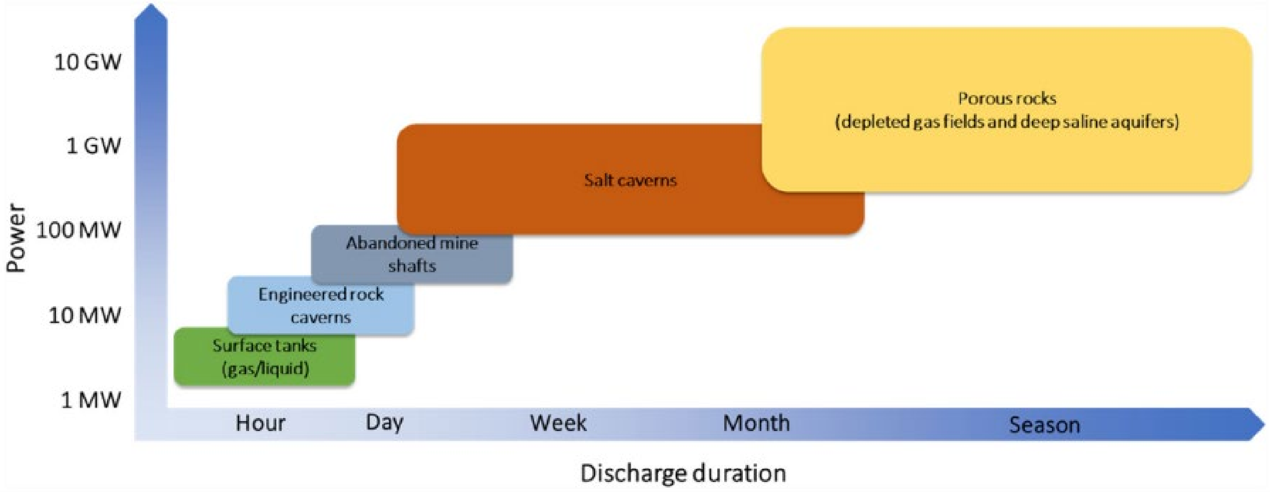


Largest geothermal plants worldwide (Statista, 2023)

Geothermal facilities (ThinkGeoEnergy, 2023)

Global UHS Projects

- Identified as a key low-carbon energy carrier, for the decarbonisation of transport, power and heating, and of fuel-energy intensive industries
- Able to compensate for the variable/seasonal nature of renewables
- Pilot projects testing UHS: 1. HyStock (Netherlands), 2. Sun Storage, RAG (Austria) and 3. Hychico (Argentina)



Geological storage options of hydrogen (Miocic et al., 2023)

World's largest underground hydrogen storage project

Mitsubishi Power Americas and Magnum Development are set to begin construction on a 300 GWh underground storage facility in the US state of Utah. It will consist of two caverns with capacities of 150 GWh, to store hydrogen generated by an adjacent 840 MW hydrogen-capable gas turbine combined cycle power plant.

AUGUST 4, 2022 EMILIANO BELLINI

ENERGY STORAGE | HIGHLIGHTS | HYDROGEN | TECHNOLOGY AND R&D | UTILITY SCALE STORAGE | UNITED STATES

The project will use Utah's unique geological salt domes to store green hydrogen in two massive salt caverns.

ROBERT GORDON UNIVERSITY ABERDEEN

CCS Operational Challenges

Sand clogs up Australia's only operating carbon capture project

Michael Mazengarb 13 January 2021 18

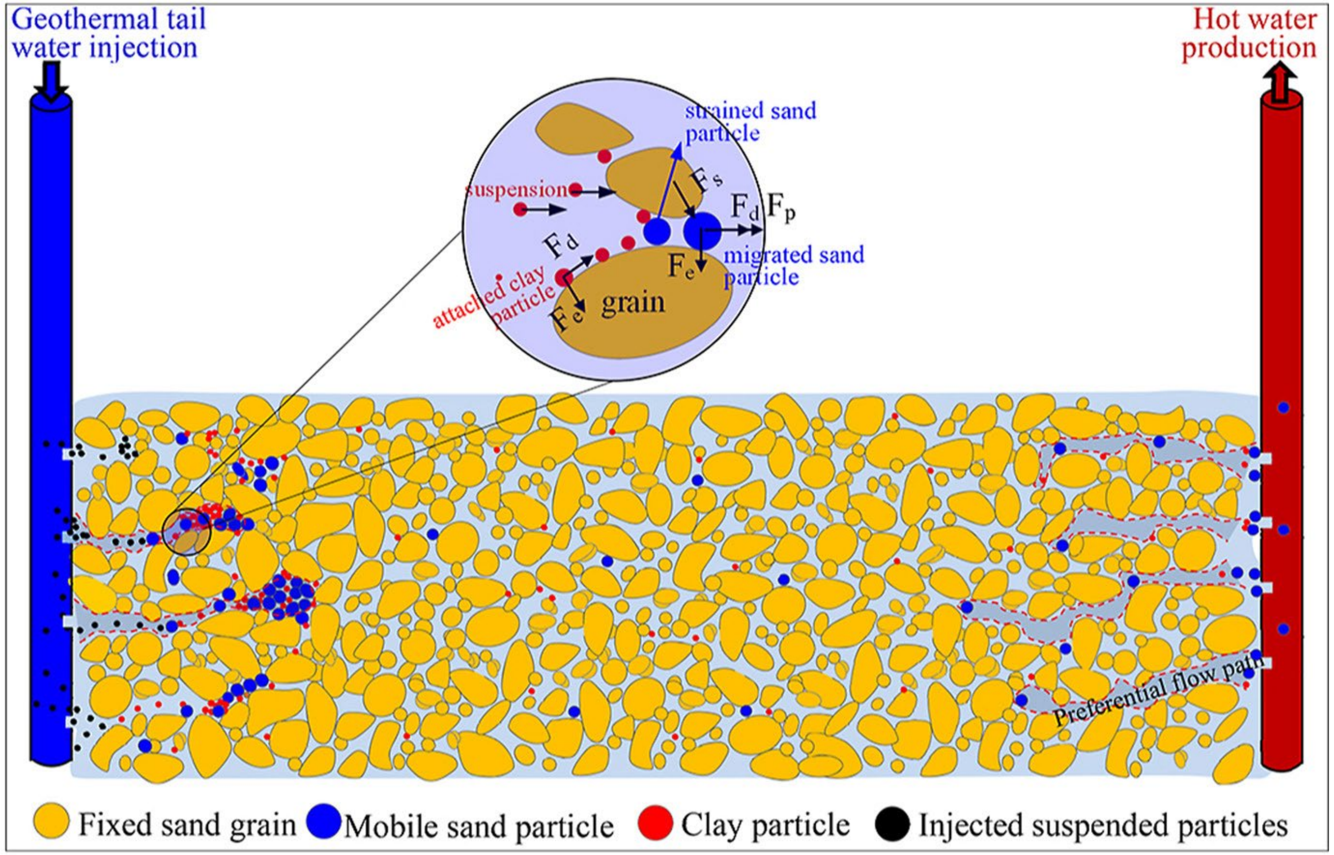
Credit: Chevron Australia

CCS Operational Challenges

- Australia's Gorgon LNG project has a capacity of 15.6 million metric tons per annum
- Capture 80% of the Gorgon LNG project's direct GHG emissions
- Required water removal from the 'Dupuy Formation' before CO_2 injection– however there was a 'significant volume of sand' preventing the water from being extracted
- Pumping equipment experienced significant issues with sand contamination
- Unknow whether it is a long-term issue, but if persistent, possible changes to the surface facilities will be required
- 800 "micro-seismic" events detected at the site, with the frequency of the seismic events increasing upon the commencement of the carbon injection activities
- 3 years behind schedule with potential cost of these delays estimated at over $100 million
- Federal government provided the project $60 million in funding

Geothermal Operational Challenges

- Cold water injection into geothermal reservoirs not only disturbs the thermal-chemical equilibrium, but also introduces or amplifies mechanical formation damage processes
- ~80% of reinjection wells have different degrees and types of blockage
- Bonding strength in most sandstone geothermal reservoirs is weak
- Invasion particles (including scale and suspended particles) in the reinjection water cause blockage



Particle migration and retention during geothermal energy exploitation (Cui et al., 2022)

Geothermal Operational Challenges

Sandstone reservoirs in **Hungary** experience a high probability of blockage:

- Less cemented
- Relatively high clay content and
- Poorly sorted grain sizes leading to

Modification of the chemical and/or physical features of the geothermal water during cooling and transport results in the reinjected containing:

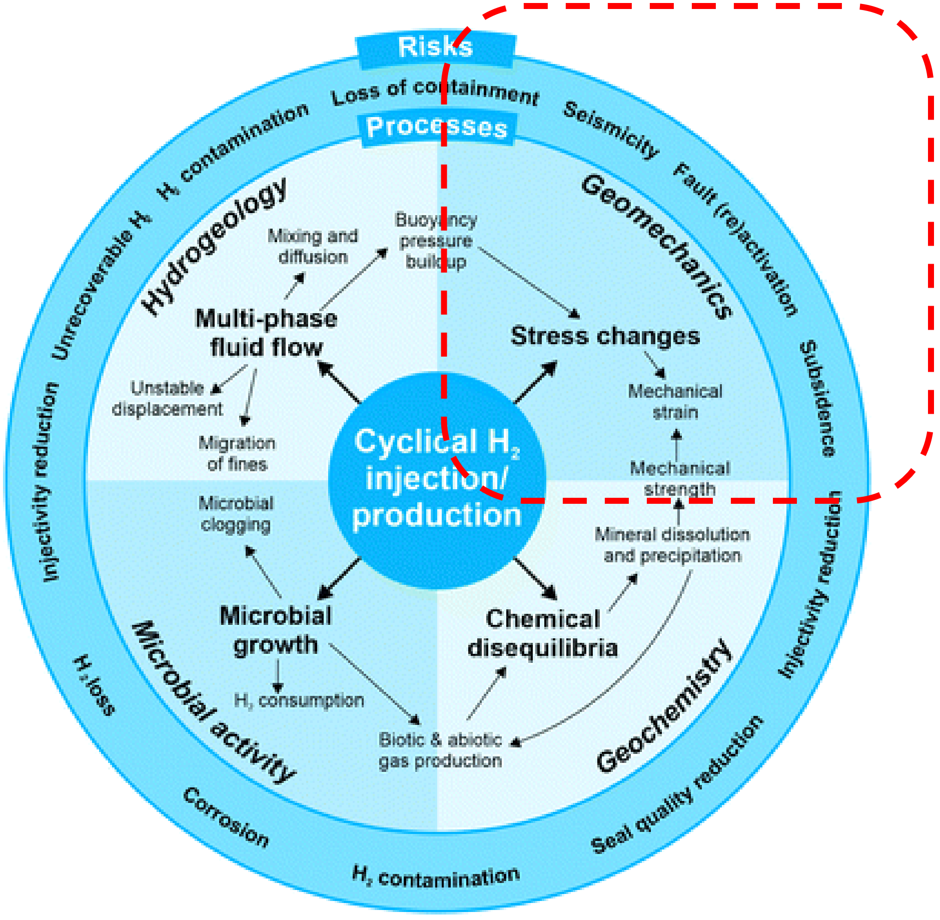
- A significant amount of suspended matter
- Scale
- Precipitations and organic separations
- Migrating solid materials in the formation

UHS Operational Challenges

Cyclical hydrogen injection and reproduction leads to:

- Cyclical pressure changes on intact and fault rock behaviour
- Short-and long-term chemical interaction of hydrogen on intact rock and faults
- Stress–strain-sorption on mechanical and transport behaviour

Repetitive injection cycles of dry hydrogen could lead to the pervasive drying out of the reservoir, particularly in the case of depleted HC reservoirs, containing mainly residual water



Impacts the mechanical behaviour and storage integrity of the reservoir

Aspects involved in the storage of hydrogen in porous media (Heinemann et al., 2021)

Sand Management Technologies

Downhole sand management techniques:

- **Baker Hughes:** GeoFORM conformable sand management system
- **SLB:**CYCLOTECH SCARPA eductive sand jetting system
- **Weatherford:** ZetaFlow ® Sand-Conglomeration Services
- **Halliburton:** PetroGuard® Mesh-DS Screen
- **3M:** Ceramic Sand Screen
- **Tendeka:** FloShroud Range

Surface filtration technologies :

- Mechanical (strainer) metal filters for the larger sized impurities and waste materials
- Cloth filters combinable with mechanical filters to catch micron-sized pollutants
- Gravel filters or sand filters, where a classified and washed bed of gravels in a steel tank catches all the impurities
- Hydrochemical filtration systems

Concerted effort required to achieve the Energy Transition
Leverage technical ‘know-how’ and expertise of the SM community

Performing while Transforming

Integration

Synergies from smartly combining uses and technologies across and within classical and new energy sectors, to boost efficiency and economic viability

Cross-uses

Synergies from transferring technologies, workflows and knowledge across businesses and disciplines

Finnish sand battery (Polar Night Energy, 2022)

Thank You for Listening!